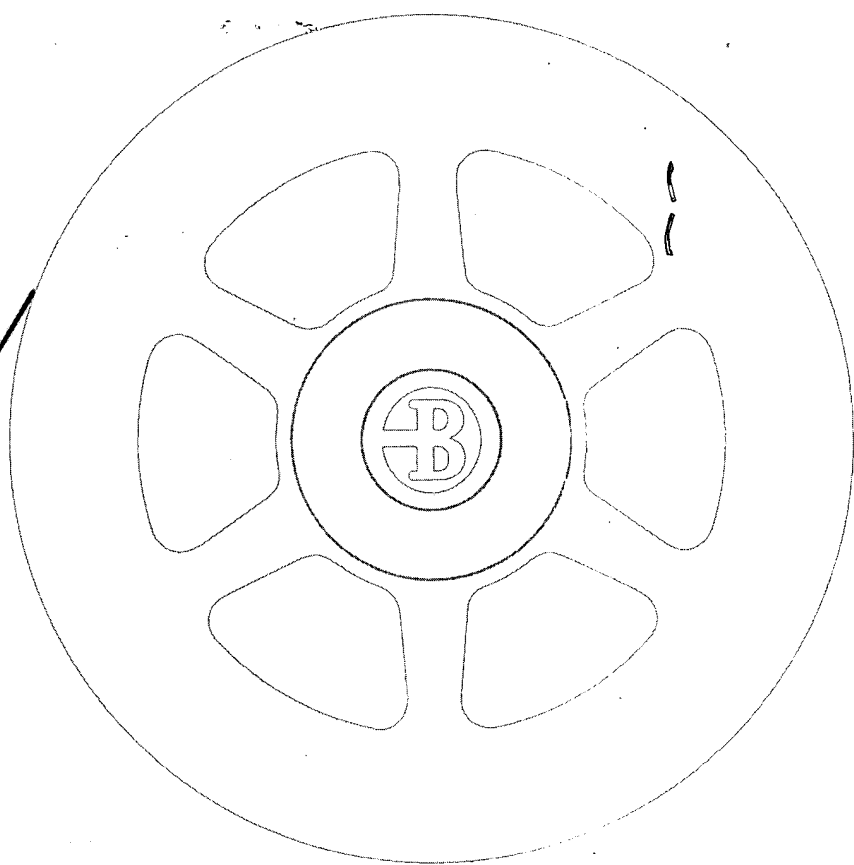
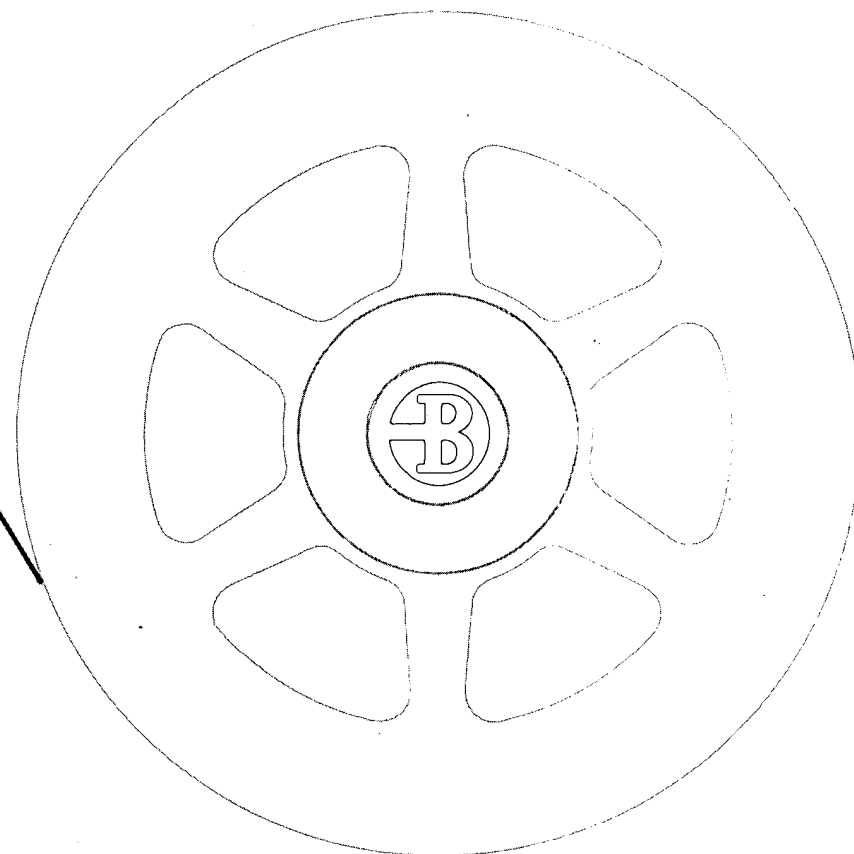


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BURROUGHS ELECTROGRAPHIC PRINTING TECHNIQUE

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DR. HERMAN EPSTEIN
MANAGER, INSTRUMENTS & CONTROLS DEPT.

RESEARCH CENTER
PAOLI, PENNSYLVANIA

PAOLI 3500

Burroughs Electrographic Printing Technique

by **DR. HERMAN EPSTEIN**
Burroughs Research Center

Summary—A set of criteria for evaluating recording techniques is reviewed. Features, applications, and the basic technique of electrographic recording are discussed.

INTRODUCTION

ELECTROGRAPHIC recording is one of the results in the continuing search for advanced recording techniques. This presentation will be concerned with the technique, as such, and possible applications to computer technology. Additional applications will be mentioned briefly.

One of the early phases in the investigation of recording techniques in the Burroughs Laboratories was a study to establish bench-marks and criteria for evaluating new developments in this field. As a result of this study the following representative criteria were chosen to compare relative merits of the developments in the laboratory as far as automatic data handling machine output is concerned:

1. Type of printer: (a) Serial input—serial output; (b) Serial input—parallel output; (c) Parallel input—serial output; (d) Parallel input—parallel output.—From the point of view of a minimum amount of buffering and control circuitry, (a) is optimum.
2. Choice of characters: (a) Numerical; (b) Alpha-merit —A full choice up to 64 characters should

be possible, rather than a limitation to the digits alone.

3. Speed of printing: (a) Characters per second; (b) Lines per second.—A technique which offers high- and low-speed recording capabilities in low-cost embodiments is desired.
4. Lines per inch.
5. Character-size.
6. Characters per lineal inch.—The technique should not significantly limit the requirements listed under 4, 5, and 6.
7. Line feed: (a) Intermittent; (b) Continuous.—Continuously moving paper during the printing cycles is normally a definite advantage.
8. Copies.—The ability to prepare copies is necessary in many applications.
9. Recording medium: (a) Type; (b) Durability; (c) Acceptance; (d) Cost; (e) Unique characteristics.—Normally, these criteria indicate that preferred media be similar to an ordinary paper stock, rather than specially prepared materials.
10. Character formation: (a) Whole; (b) Matrix.—Depending upon the point of view, one or the other of these character formations is preferred.
11. Actuator of actual recording mechanisms: (a) Electromechanical; (b) Electric pulse; (c) Light flash; (d) Motor driven; (e) Other.—There are more inherent limitations in (a), (c), and (d) than in (b).

12. Selection of the printing actuator: (a) Electro-mechanical; (b) Electronic.—Normally, electronic selection is desired and is, indeed, necessary for high-speed devices.
13. Machine limitations: (a) Number of rectifiers; (b) Number of tubes; (c) Mechanical complexity; (d) Cost; (e) Unique features.
14. Applications.—The breadth of application of the technique is, of course, important.
15. Required type of pulse input from information source.—The technique should be capable of making use of general input rather than be limited to outputs of specific devices or media, such as punched tape.

Another result of the study indicated that the most universal technique, if such exists, consistent with the above criteria, would be an electrostatic technique in which the actual recording, as such, is accomplished without moving parts. In addition, basic to a concept evolved from the study was that the recording should be done while the paper is moving and that alphameric symbols should be formed from a matrix array of dots. Continuously moving recording paper and matrix arrays tend towards economical embodiments, particularly for designs aimed at the higher printing speeds. Incidentally, the matrix character formation also makes direct character recognition more feasible.

An electrostatic process has at least several basic inherent advantages:

1. High-speed capabilities.
2. Low power dissipation.
3. High physical forces in the electric fields.

DISCUSSION OF THE TECHNIQUE

The electrographic recording technique appears to satisfy the criteria set forth very favorably. The features of the technique are listed as follows:

1. It is a high-speed technique; a mark can be put on paper in a duration as small as one microsecond, and printed characters formed from a 5 by 7 matrix can be recorded at rates exceeding 5,000 characters per second. For instance, recording rates at hundreds of inches per second of paper strip is potentially possible.
 2. The only motion involved in the technique is the continuously moving paper under the printing head.
 3. The system is basically low in cost.
 4. The system consumes very little power; the power required to print 5,000 characters per second, serially, is about 5 watts in addition to that necessary to move the paper and fix the recorded images.
 5. The system is relatively quiet; the only noise is due to the moving paper.
 6. The printing technique does not involve any messy, wet, or damp processes.
 7. Permanent recording with no fading is achieved.
 8. No wear of electrodes or the like is involved.
- The electrographic recording technique produces con-

trolled, visible dots by electrical pulse means directly. In its essentials, the process utilizes a controlled source of charge to form small charged areas on a high-resistivity surface such as a coated paper. The electrostatic latent image formed by the charged areas is made visible by inking with a single suitable powder and made permanent by thermal fixing. In applications in which the images are to be erased and the medium reused, the thermal fixing stage is eliminated. Fig. 1 shows the rudiments of the technique. During the recording stage the electrical discharge from the point electrode to a grounded metal plate is used as the source of charge to form the electrostatic latent image on the high-resistivity paper surface. The size and shape of the image depend mainly upon the polarity, the electric field strength and the surface coating used on the paper. A relatively low negative voltage applied to the point electrode gives small round dots suitable, for instance, for high-speed matrix printing. The recording medium is a relatively low-cost, uniformly and smoothly coated paper. The coating is a colorless, high-resistivity, thermoplastic coating. The thermoplastic feature of the coating in combination with a suitable ink and appropriate heat processing makes it possible to make the developed electrographic image completely permanent. The electrographic ink consists of a single powder consisting of material colored as desired. To ink the latent image the paper is passed through an inker containing the powder to give a visible image with virtually no background discoloration. The image is made permanently visible by passing the inked paper over a temperature-controlled hot plate. The three steps in the recording process are necessarily consecutive and are performed as the paper moves continuously at the appropriate speed for the particular recording application.

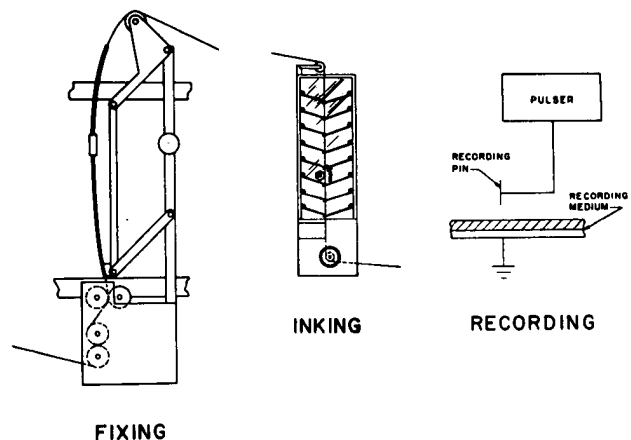


Fig. 1—Rudiments of electrographic printing.

Fig. 2 illustrates the recording head structure and the 5 by 7 matrix character formation. The recording head in this case is a set of seven 0.005-inch diameter flat-faced wires in a row, maintained at a fixed distance from the surface of the continuously moving paper. The figure shows sketches of the head. The character is built

up by five successive choices of the seven pins. Fig. 3 is the electronic pulsing circuit; one is used for each pin. The circuit consists of one standard tube transformer coupled to the printing pin. A 250-volt supply voltage is used with an input voltage of the proper duration and amplitude; for instance, 40 microseconds and 20 volts. A voltage bias below the recording threshold is maintained at the printing pins. This allows the use of smaller pulses and closer pin spacing in the head.

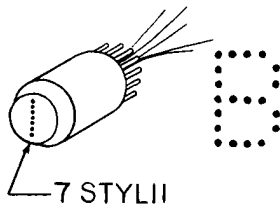


Fig. 2—Recording head structure.

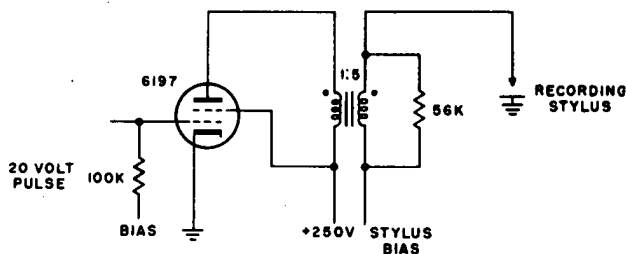


Fig. 3—Electronic pulsing circuit.

There are other features of the technique which may be of interest in special applications:

1. The latent electrostatic image and inked visible image will remain on the paper for a long time before fixing.
2. The powdered ink and corresponding electrostatic image can be erased, if desired, and new information recorded on the same medium. Of course, at any time, the inked image on the medium can be made permanent by carrying through the heat fixing.
3. It is possible to detect latent image electrically before inking. Thus, the technique offers possibilities for use of the recorded medium after each stage of the process; that is, recording, inking and fixing.

Fig. 4 shows a 5 by 7 magnetic matrix and decoding unit to buffer the pulsing circuits to the pins and the information source. The high pulsing rates made possible by this printing technique allow reasonably high recording speeds to be obtained with seven pins in five pulse times, using one decoding matrix and one 5 by 7 magnetic matrix. This results in a small-size, low-powered, cheap recording device. If straight parallel printing with a buffer unit for each channel is used, then phenomenally high speeds are made possible. In fact,

the limitation becomes the speed at which paper can be handled.

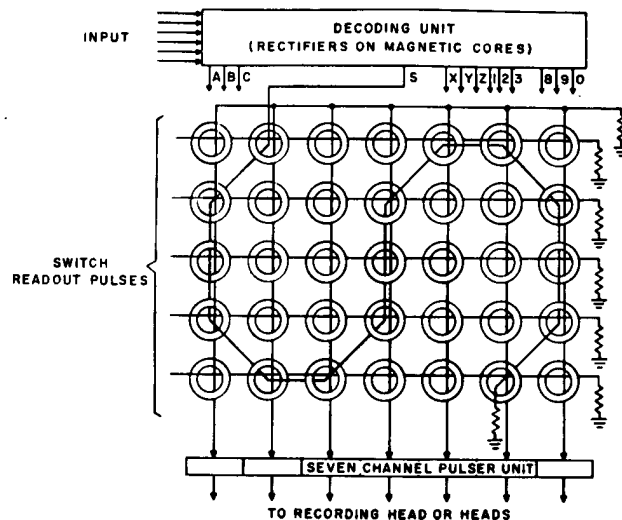


Fig. 4—Decoding unit.

APPLICATIONS

Fig. 5 is a picture of the laboratory model which has been used in the investigations of the technique. Some other applications of the particular technique are as follows:

1. High-speed labeling or strip-printer applications.
2. Digital computer output systems.
3. Page-printer applications including plotters.
4. Teletyping and telemetering applications.
5. High-speed strip-chart type of recorder.
6. Facsimile applications.
7. Applications in which the capabilities of high-speed recording coupled with high-speed reading (photoelectric or magnetic reading) are necessary, made possible through the use of a dark-colored magnetic inking powder in the technique.

ACKNOWLEDGMENT

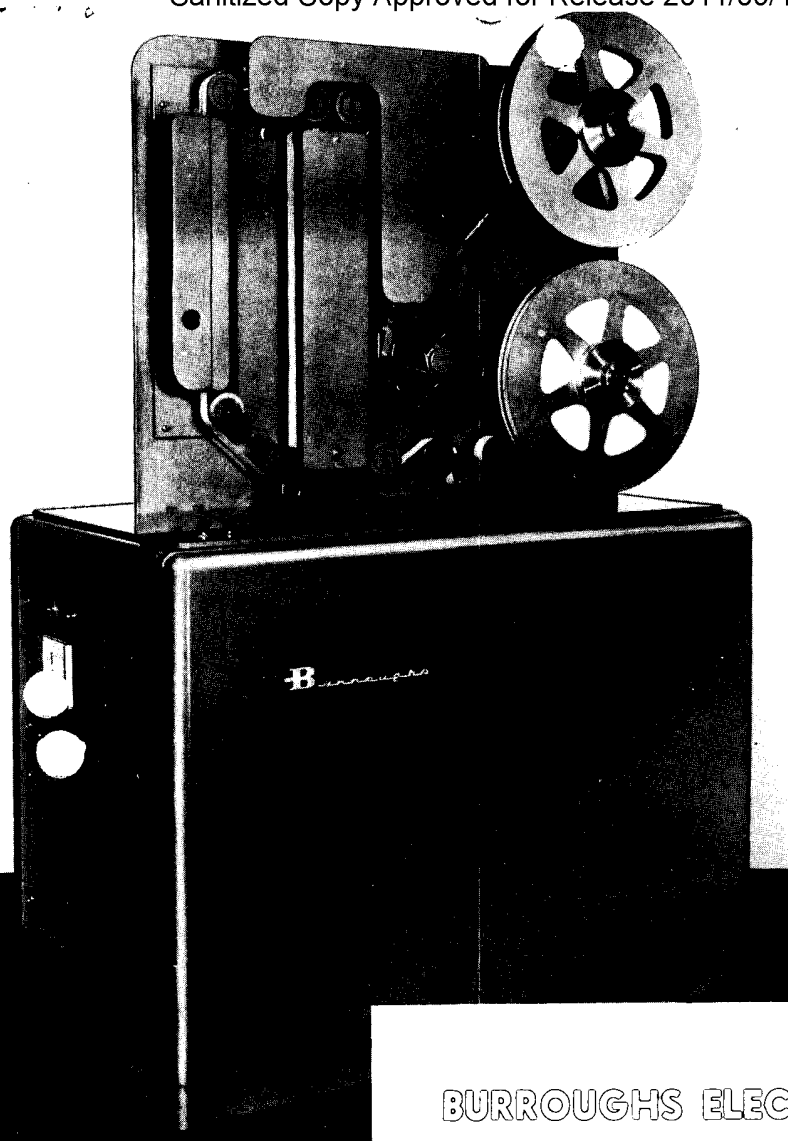
The author would like to acknowledge the contribution to the development of the subject technique by F. Innes, R. Phelps, and O. Stram.



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BURROUGHS ELECTROGRAPHIC PRINTING TECHNIQUE

The Burroughs Electrographic Printing Demonstration Unit has been constructed to display the speed and simplicity of the electrographic printing technique. This technique has been under study at the Burroughs Research Center for a number of years and has already been applied to prototype systems.

Burroughs Electrographic Printing Unit

The Demonstration Unit is a self-contained machine which prints on paper tape continuously moving at 100 inches per second. The permanent recording is made without resorting to any messy or hand processes. Visible images in controlled configurations are recorded on the paper surface in accordance with the input information. Ultimate printing speeds are very much greater than those speeds demonstrated on this unit and are limited primarily by the rate at which the paper tape can be moved.

Information printed in this demonstration unit is derived from a program stored on a small magnetic drum. Letters, numbers, lines, or graphic information to be printed can be derived from almost any source using suitable electronic buffering equipment to convert the source data into the desired electrical signal for printing. The electrographic printing head contains seven writing pins-- the ends of fine wires. The printing head makes no physical contact with the paper assuring extremely long life of the head. Because the actual

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printing is electronic, the only noise surrounding an electrographic printer is generated by the particular tape-transport system and any ventilating equipment employed.

A brief examination of the printed tape produced by the Demonstration Unit will show how the individual dots from each writing pin are blended by the eye to show matrix-formed characters. The simplest mark is the period -- the bottom pin is pulsed alone. The "B" shows how five columns of dots and blanks are combined to form the letter as the tape moves across the printed area: first, to form the leading edge, all seven pins are pulsed once; then, only the first, fourth, and seventh are pulsed three times; and finally the closing loops are formed by activating all the pins except the first, fourth, and seventh. Space between characters is obtained by allowing the tape to move the width of two columns; the space between words is equal to seven columns.

A picture of the demonstration equipment together with a sample of its printing are shown on this sheet.

THE TECHNIQUE

The basic technique of electrographic printing consists of passing the paper between a metal plate and printing head, and applying an instantaneous potential to form a latent image on the paper surface. This latent image is made visible to the human eye by dusting the paper with a colored

powder. The powder clings to the spots on the surface which were "printed". The dots of powder form a permanent image when small amounts of heat and pressure are applied. All of these simple processes -- recording, dusting, and fixing -- are accomplished as fast as the paper is moved from the supply reel, past the printing head, through the powder, and across the heater and cooling wheel.

APPLICATIONS

The Demonstration Unit proves that visible information can be produced on paper at high speeds. The applications of this ability are essentially engineering jobs. An electrographic printer can be most gainfully employed where visible information must be produced economically at high rates of speed. Because the printer can make a permanent record as fast as the information is made available, intermediate storage will not often be necessary. The output of a computer or monitoring device, for example, can be ready for use almost instantly. The basic capability of producing visible information on paper at high speed by electrographic printing suggests many applications in business, industry, and communications.

For further information see, "The Electrographic Recording Technique," by H. Epstein, published in the Proceedings of the Western Joint Computer Conference, Los Angeles, California, March 1955.

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RESEARCH CENTER
PAOLI, PENNSYLVANIA